

Thermo-Mechanical Modeling and Analysis for Turbopump Assemblies



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Concepts NREC

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Outline

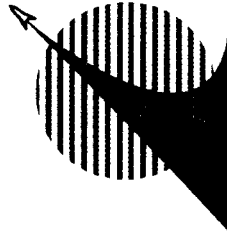
- Technical Need
- Project Goals
- Technical Approach
- Development Status
- Conclusion



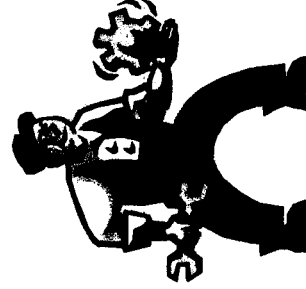
Project Support



- NASA SBIR, through TD61
- Spin-off to IHPRPT
- Spin-off to industry



Space Transportation Directorate
TD61, Functional Design Group,
Turbomachinery



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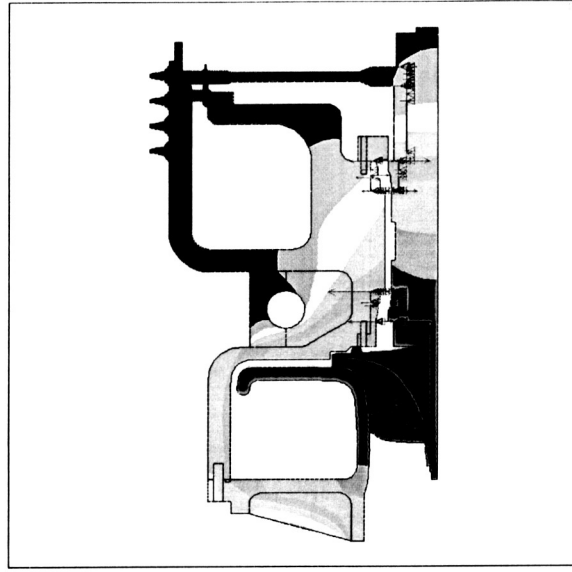
Technical Need

- Life, reliability, and cost are strongly impacted by steady and transient thermo-mechanical effects
- Design cycle can suffer big setbacks when working a transient stress / deflection issue
- Balance between objectives and constraints is always difficult
- Requires assembly-level analysis early in the design cycle



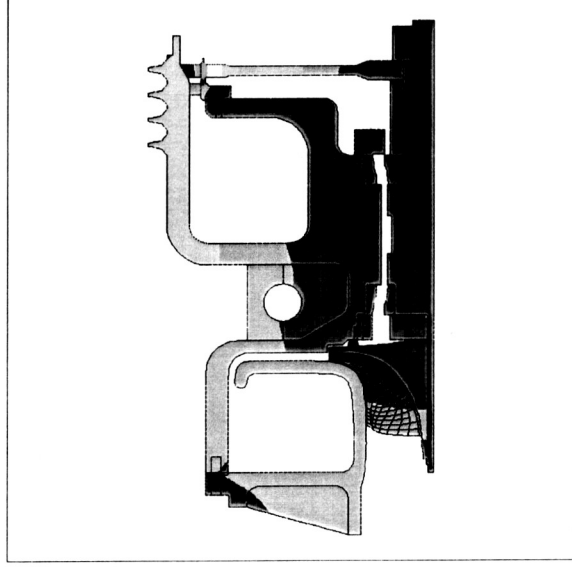
Technical Need – Operating Point

Temperature



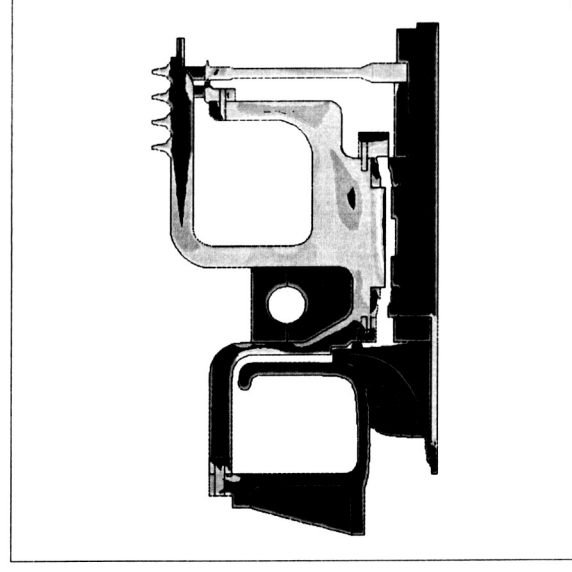
Absolute temperature limits and thermal gradient limitations

Displacement



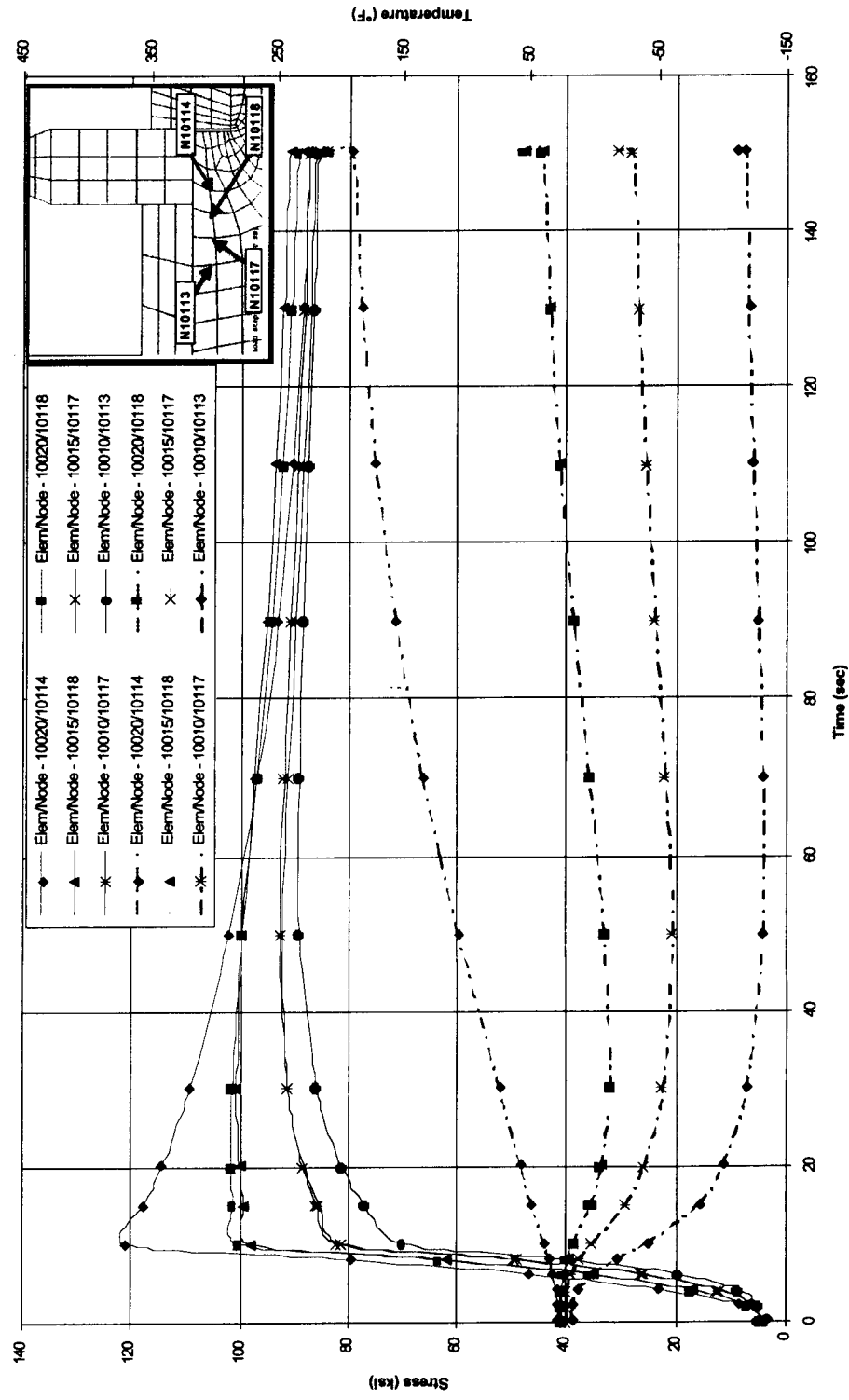
Critical clearances, fits and gaps

Stress



Stress margins, LCF life, HCF margin, preloads

Technical Need - Transient



Project Goals

- Develop thermo-mechanical modeling software tools
 - Push thermo-mechanical modeling earlier in the design process
 - Reduce cost and risk of designs
 - Improve life and reliability of propulsion systems
- Integrate existing tools
 - Improve the design process
 - Open system for 3rd party software



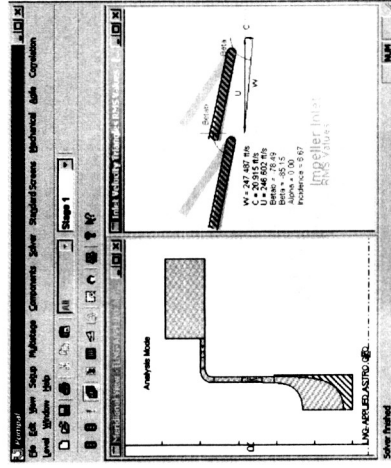
Technical Approach

- Design data and results flow from component analysis tools to the assembly model
- Software operates in a collaborative environment
 - Data-centric approach to multi-disciplinary analysis
 - XML provides flexible open data format
- Integrate with CAD data
 - Parasolid kernel
- Integrate with multi-disciplinary optimizer

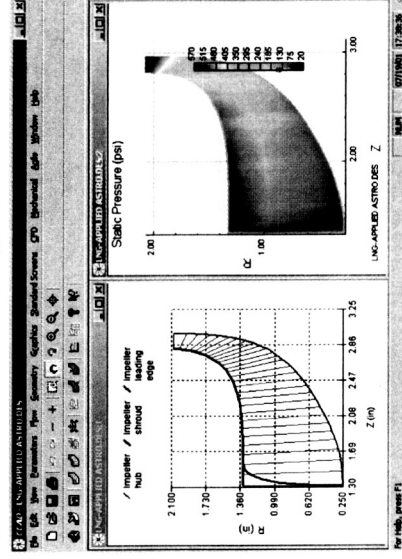


Data Flow to Assembly

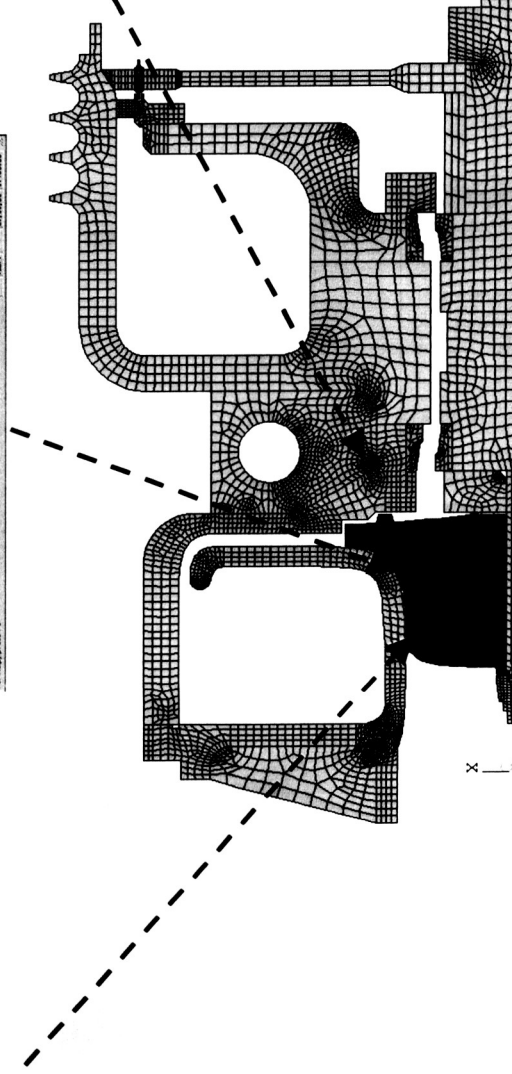
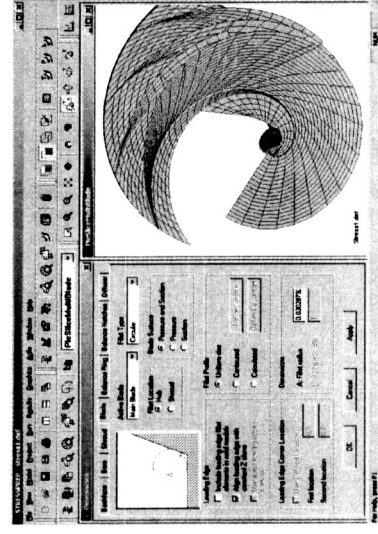
Meanline



3D Blading & CFD



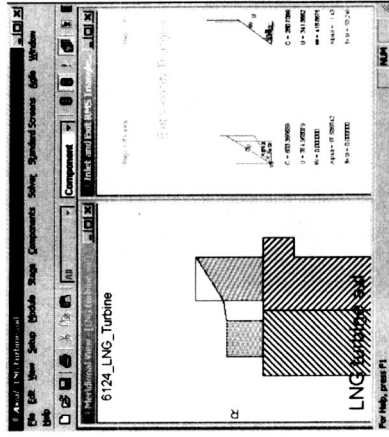
Stress & Vibration



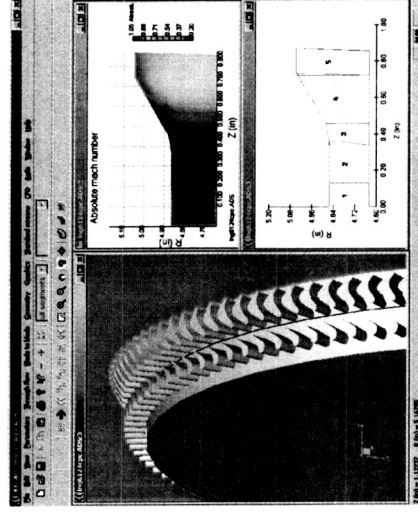
CONCEPTS NREC

Data Flow to Assembly

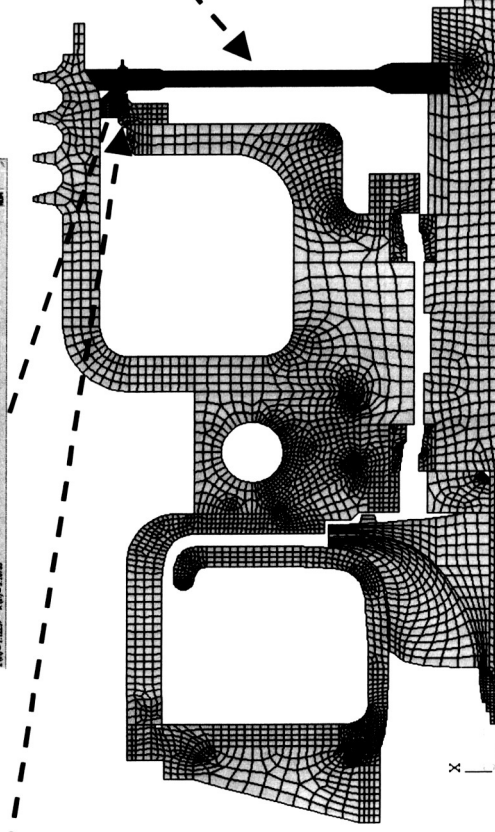
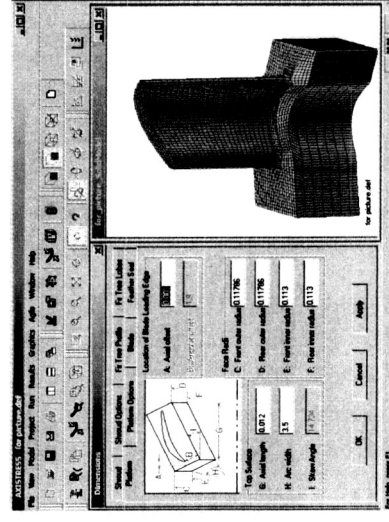
Meanline



3D Blading & CFD

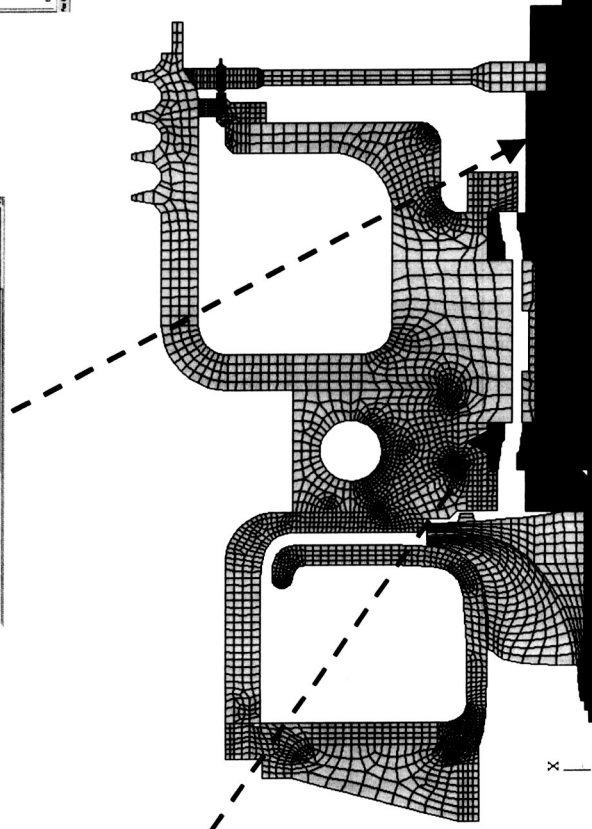
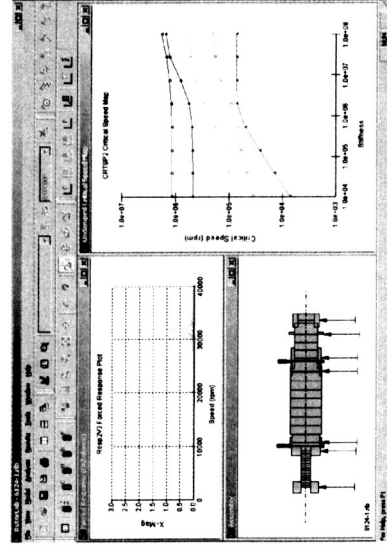
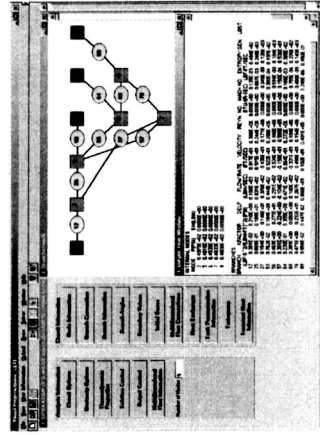
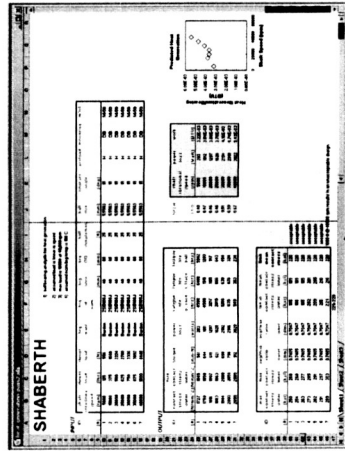


Stress & Vibration

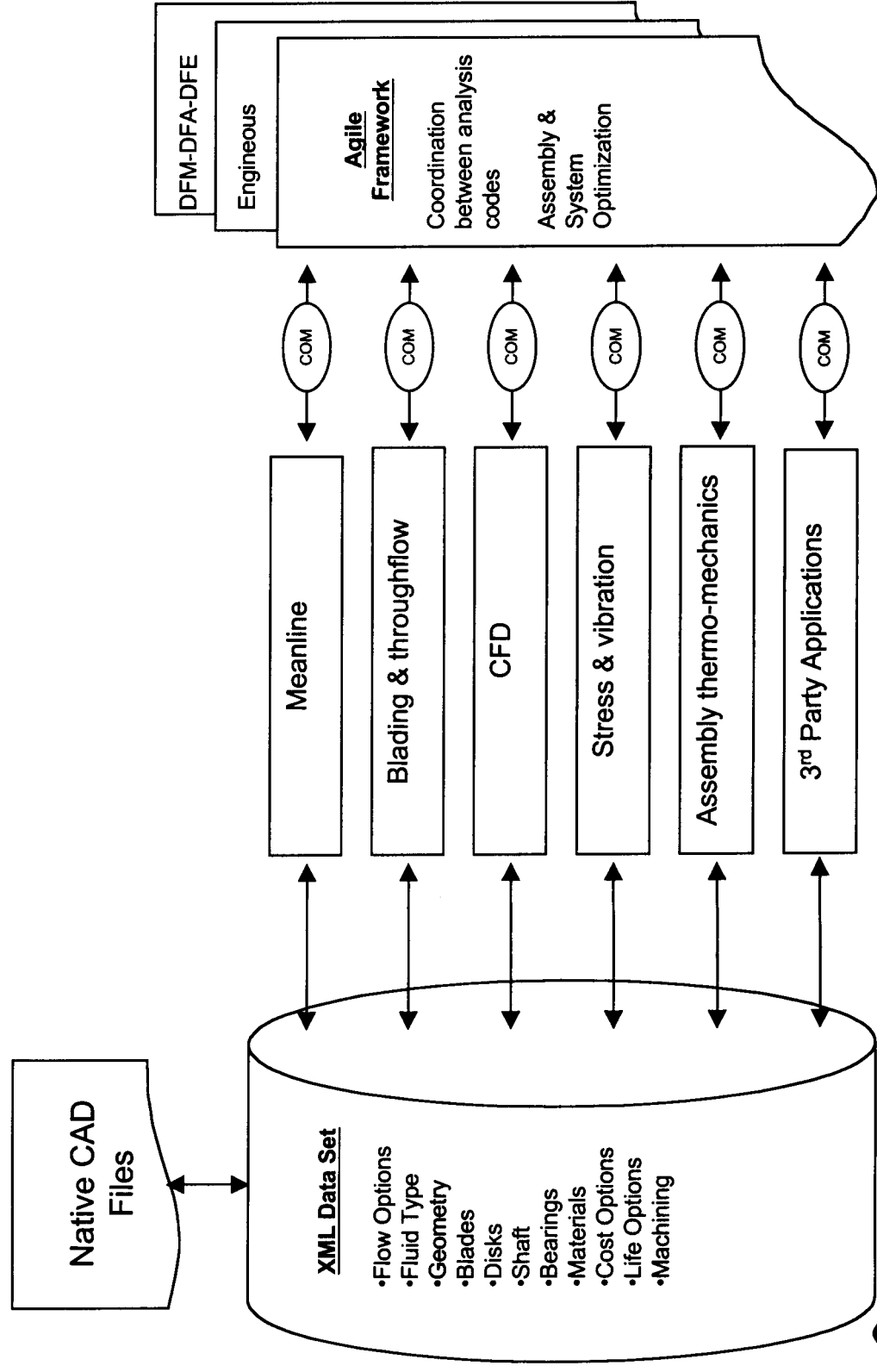


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Data Flow to Assembly



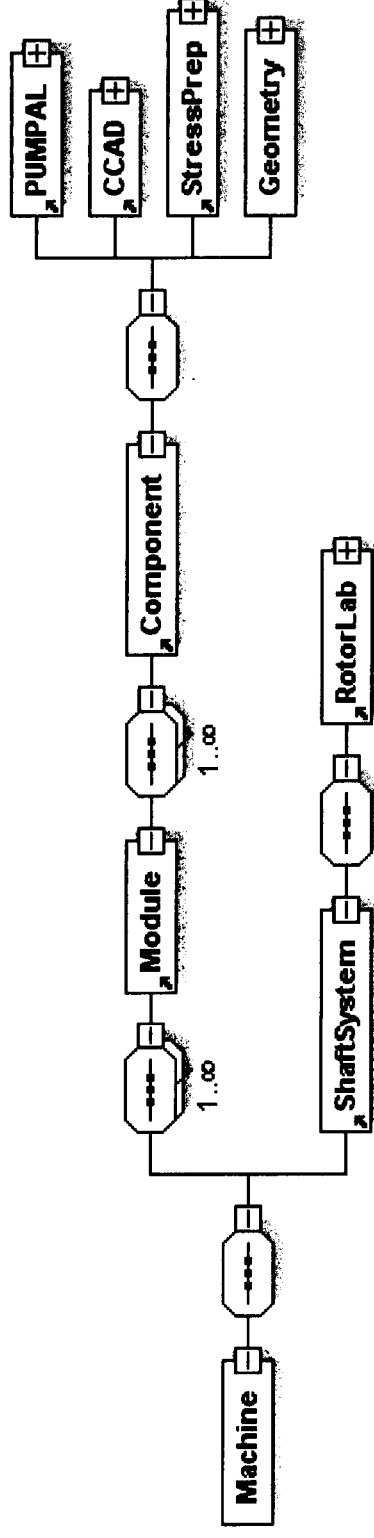
Data-Centric Organization



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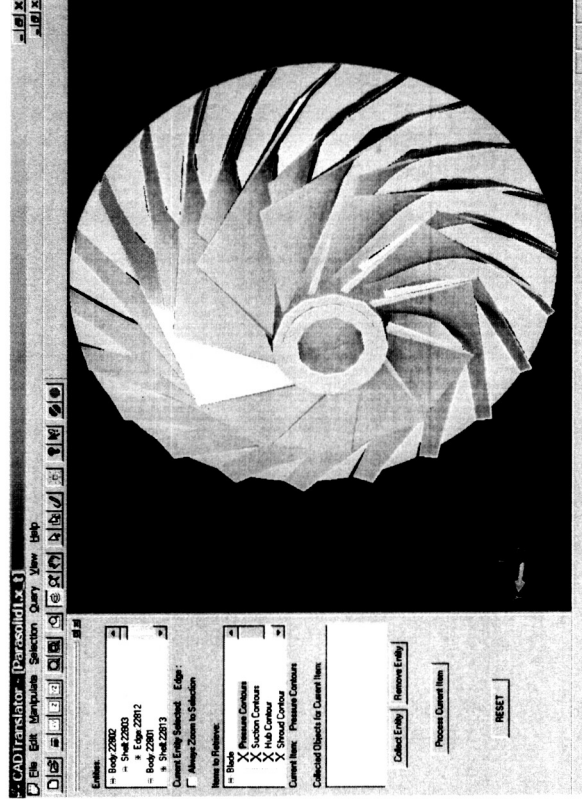
XML Data Set



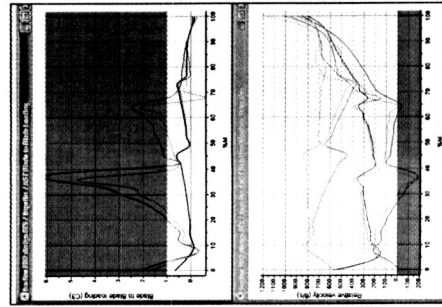
- Flexible, recursive data tree stores geometry, modeling parameters, and results from different disciplines.
- XML provides robust open technology for data sharing
 - Format is self-descriptive and self-checking
 - Growing supply of XML tools for C++, Java, Perl, Python

CAD Integration

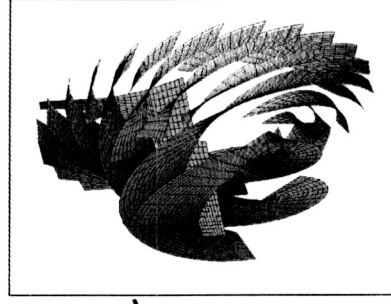
- Import/export of CAD files can be time consuming and error prone.
- Individual tools can become segregated from design data flow (more time lost in the design cycle).
- Using Parasolid geometry kernel from EDS Unigraphics:
 - Robust geometry functions for curves, surfaces, volumes
 - Read native files from Unigraphics
 - Use IGES for other CAD systems



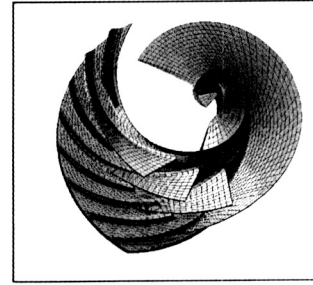
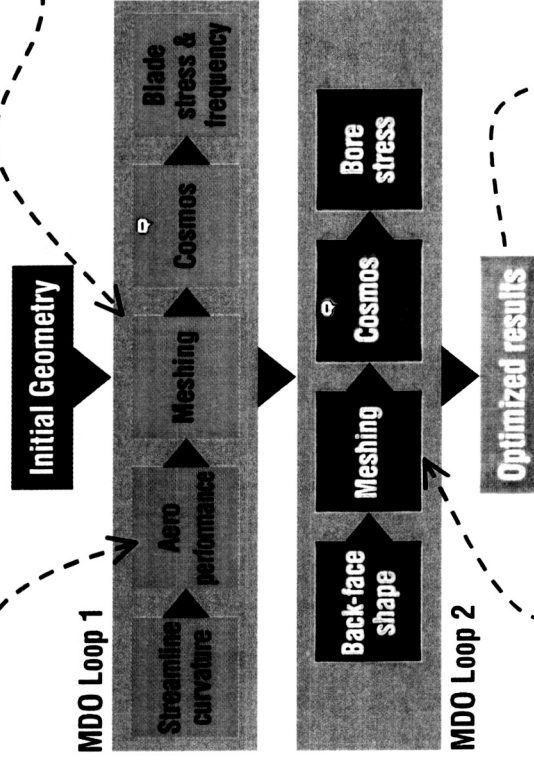
Multi-Disciplinary Optimization



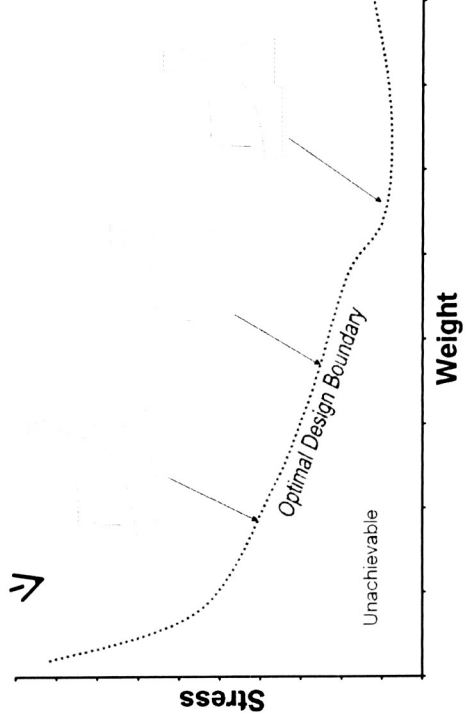
Quasi-3D
aero model



Quasi-3D
FEA model



Solid FEA
model



Conclusion

- Software tool integration will push thermo-mechanical modeling upstream in the design process
- Open format data-centric approach has many advantages for sharing design data and results
- CAD integration provides a crucial link the the design process
- Software integration enables automated multi-disciplinary design trades

